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Content analysis of video sequences is a critical component of virtually any application involving the management of large video data sets. Systems for managing video databases or transmitting large numbers of video sequences are most efficient if they incorporate some understanding of the video content. The required analysis must be automated if large volumes of video are to be accommodated. This report presents two contributions of this project to problems in video content analysis. The first is an algorithm for fast estimation of scene boundaries in video sequences. The second is an approach for using video content and short-term traffic statistics to improve bandwidth allocation when transmitting video over the internet.

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Sincerely,

Prof. Michael T. Orchard
Dept. of Elect. And Comp. Engineering
Rice University

Final Progress Report:
Content Analysis of Video Sequences
Army Research Office ASSERT Award DAAG55-97-10208

This project supported the graduate research training of Robert Joyce, who is completing his Ph.D. studies in the Department of Electrical Engineering at Princeton University. Mr. Joyce began his graduate studies with interests in wavelet-based processing for multimedia sources (particularly, images and video), but his research evolved to focus on the problem of content analysis of video sequences. His research contributions on this problem have been supervised by Prof. Bede Liu at Princeton University, with collaborations both with me, Prof. Michael Orchard (currently at Rice University), and Prof. S.-Y. Kung at Princeton. His work with Prof. Liu has produced a conference paper [3] and a journal submission [1], proposing new, low-complexity algorithms for detecting scene changes in video sequences. Mr. Joyce's collaborations with Prof. Kung's group has produced two conference papers [4, 5] and a journal publication [2]. This work applies video content analysis to guide dynamic resource allocation for transmission of video over the Internet.

Content analysis of video sequences is a critical component of virtually any application involving the management of large video data sets. Any system for indexing, browsing or searching video databases requires that video content be analyzed at some stage to identify key shots and scene changes, and this analysis should be automated if huge databases are to be accommodated. Perhaps less obviously, efficient allocation of network resources for transmitting a large number of video sequences can be aided by incorporating some understanding of the organization of video content within each sequence.

Mr. Joyce's papers [1, 3] propose a fast, new approach to identifying shot and scene boundaries in a video sequences. The approach addresses all scene changes, abrupt cuts as well as gradual transitions of various types: dissolves, fades, wipes, etc. The new approach operates on a compressed video representation, requiring only partial decoding of the compressed video stream and allowing it to operate faster than real time. Simulations show that the accuracy of the new approach is comparable to that of previously known algorithms that have much higher complexity.

Mr. Joyce's papers [2, 4, 5] propose an improved approach to allocating network

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resources for transmission of video sequences. The accuracy of any resource allocation method depends critically on its prediction of future traffic patterns. This work proposes a systematic approach to predicting future video traffic patterns based on both an analysis of video content and available short-term bandwidth statistics. Experimental results show a smaller mean-square resource prediction error and higher overall link utilization. The journal paper [2] appears in a special issue of *IEEE Trans. on Multimedia* focusing on "Multimedia over IP".

1 Personnel

Mr. Robert Joyce was the only person funded on this project. Mr. Joyce's participation in this project contributed to his earning the M.A. degree in Electrical Engineering from Princeton University in November, 1999. The research of this project, and continuing research, are supporting Mr. Joyce's candidacy for the Ph.D. in Electrical Engineering, which he expects to receive in 2002.

References

[1] Robert A. Joyce and Bede Liu, "Temporal segmentation of video using frame and histogram-space," submitted to *IEEE Trans. on Multimedia*, July 2001

[2] Min Wu, Robert A. Joyce, Hau-San Wong, Ling Guan, an S.-Y. Kung, "Dynamic resource allocation via video content and short-term traffic statistics," *IEEE Trans. on Multimedia,* vol. 3, no. 2, pp. 186-199, June 2001.

[3] Robert A. Joyce and Bede Liu, "Temporal Segmentation of Video using Frame and Histogram Space," *Proc. IEEE Int'l Conf. on Image Processing*, Sept. 2000.

[4] Min Wu, Robert A. Joyce, S.-Y. Kung, and Ling Guan, "Dynamic Resource Allocation via Video Content and Short-Term Traffic Statistics," *Proc. IEEE Int'l Conf. on Image Processing*, Sept. 2000.

[5] Hau-San Wong, Min Wu, Robert A. Joyce, Ling Guan, and S.-Y. Kung, "A Neural Network Approach for Predicting Network Resource Requirements in Video Transmission Systems," *Proc. IEEE Pacific Rim Conference on Multimedia*, Dec. 2000.